

Weather

Attendees

Richard Blakeslee	rich.blakeslee@nasa.gov	256-961-7962
Judith Curry	curryja@eas.gatech.edu	505-986-0399
Al Gasiewski	al.gasiewski@noaa.gov	303-497-7275
Gerry Heymsfield	gerald.heymsfield@nasa.gov	301-614-6369
Robbie Hood	Robbie.Hood@nasa.gov	256-961-7959
Chris Nagy	christopher.j.nagy@nasa.gov	661-276-2626
John Sharkey		
Joe Totah	Joseph.J.Totah@nasa.gov	650-604-1864

- Note: Robbie Hood (Lead)

Weather

Critical Science Questions

Existing Roadmaps: *Given what we have heard about UAV potential, what of the 2007-2015 Roadmap goals could be addressed from a SUBORBITAL platform?*

- Data void
 - Regions
 - Northwest Pacific
 - Eastern Pacific Arctic
 - Atlantic Ocean
 - Antarctic forecasting (research)

Weather Phenomena

Tropical genesis areas

Process study

Frontal systems

Squall lines

- Vertical, horizontal resolution
- Up-stream
- Variables
 - Temperature
 - Moisture
 - Winds
 - Pressure
 - Ozone
 - Aerosol Particle concentration
 - Precipitation
 - Electrical / Lightning
 - Cloud microphysics
 - Sea Surface Temperature and surface winds in hurricane
 - Soil Moisture (watershed resolution for agriculture)
 - Vertical velocity

Other Roadmap Possibilities: *Are there other things that should be in the Roadmap now that we see what is possible?*

- Chemical weather event (volcanoes, forest fires, sudden events)

Phasing Observations: *How would we phase the critical observations in our Earth Science focus area that are most suitable for the suborbital platform realm?*

Weather

Critical Science Questions

- Hurricane genesis, evolution, and landfall
- Targeted, adaptive observations
- Focused observations in extreme weather (squall lines, tornadoes, frontal systems)
- Forecast initialization in data sparse regions
- Chemical weather events (volcanoes, forest fires, sudden events)
- Cloud microphysics process studies

Weather – Cloud Microphysics / Properties

Critical Observation: Cloud microphysics/properties

Observation / Measurement Definition: Describe the phenomenon you want to observe. Describe what you need to measure.

- Measurements of turbulence, vertical velocity
- Particle size distributions, habit, phases
- Liquid/ice contents
- High accuracy thermodynamic information
- Electrical and radiation measurements
- Coordinated with higher altitude remote (or low altitude looking up) and/or satellites

Explicitly state how this observation and measurement supports this Earth Science focus area.

- Key to observations of tropical rainfall and energy release
- Key to processes of rain particle growth
- Improvement of satellite algorithms
- (Stratospheric water exchange)
- *Caveats:
 - Build better forecast and retrieval schemes (vs. water and energy breakout)
 - Real-time parameterization

Explicitly state the advantage of using a suborbital platform for this measurement.

- Human safety
- High altitude aircraft and/or satellite
- Lower altitude

Identify other cross-cutting areas impacted by this observation.

- Water and energy
- Atmospheric composition
- Regional numerical weather models

Weather – Cloud Microphysics / Properties

Observation / Measurement System Requirements: Describe how you want to observe or measure the phenomena. Consider the following:

Instrument / Payload characteristics (type, weight, volume, environmental considerations, and access such as sampling or viewing ports)*

- See Hurricanes for mothership
- On penetrating platforms (requires controlled descent and safe recovery at locations of opportunity, including automated landing site selection)
 - Microwave sensors (optional)
 - Particle size probes
 - Laser hygrometer
 - Radiation pyrometers
 - Electric field sensors/probes
- Hardened to severe environments (e.g. electrical, icing, turbulence)
- External pods
- Needs to be included under aircraft characteristics (no place in template for this)

Flight characteristics (location, altitude, endurance, season, frequency). Discuss number of platforms, formation flying, or other special flight characteristics.

- Penetrating platforms controlled by a higher altitude platform (e.g. mothership, perhaps including Scaled Composites' White Knight) or controlled by ground-based instrumentation (e.g. radars)
- Aircraft should be able to be launched (from another aircraft) and takeoff or land autonomously
- Coordinated flying of high altitude platform relative to penetrators
- Hardened to severe environments (e.g. electrical, icing, turbulence)
- Flight profiles – spiral or horizontal, with loiter capability in ice region
- Slow airspeed (~100 kts), but maneuverability against headwinds

Communication needs such as real-time data or instrument control

- See Hurricane mission for overall requirements
- Aircraft to aircraft high bandwidth/line-of-sight (LOS) or high bandwidth air-to-ground/LOS if controlled by ground-based radar
- Penetrators capable of different flight profiles, supervised by mothership or ground-based instrumentation
- On-board partial processing and telemetry

Weather – Cloud Microphysics / Properties

Mission Concept: Describe in as much detail as possible the measurement approach:

Provide a narrative describing a “day-in-the-life” of the mission.

- Two scenarios:
 - Takeoff from existing runway, completes mission, and lands
 - Deployed from mothership, completes mission, and lands at sea or on land
- Aircraft readiness – near on demand (2-3 hrs)
- 20nm stacked, layered lines (horizontal) over 500nm range, maximum 5 hrs duration (assuming 100 kts TAS)

Develop a diagram showing flight profile or maneuvers in time, space and/or geographic coordinates.

(no input)

Identify any special or unique platform or mission issues

- Hardening
- Either spiral or horizontal
- Potential launch from mothership
- Coordinated with other remote sensing instrumentation

Summarize the key elements of the mission concept for this measurement.

- Coordinated flights with remote sensors
- Dangerous research mission (fly in the middle of a storm, but only means of observing cloud microphysics accurately)
- Potential operational applications for regional modeling and severe storm warning

Weather – Extreme Weather

Critical Observation: Focused observations – extreme weather

Observation / Measurement Definition: Describe the phenomenon you want to observe. Describe what you need to measure.

- Process studies involving severe and hazardous weather events to improve the physics in mesoscale models (parameterizations)
- High altitude remote sensing – precipitation, clouds, meteorological sounding, electrical, microphysics, dropsondes when possible (over ocean)

Explicitly state how this observation and measurement supports this Earth Science focus area.

- Improve parameterizations for mesoscale models
 - Winter storm hazards determine at local levels for appropriate mitigation
 - Regional forecasting of rain and snow accurate for economic decisions

Explicitly state the advantage of using a suborbital platform for this measurement.

- Remote sensing measurements for long duration
- Human safety
- Higher spatial and temporal resolution sampling
- Continuous observation
- Long endurance and range
- Real-time telemetry and on-board processing (sensor web)

Identify other cross-cutting areas impacted by this observation.

- Numerical weather prediction
- Water and Energy Cycle
- Satellite validation (GPM, CloudSAT/CALIPSO, Aqua, NPOESS)
- Atmospheric composition (water vapor)

Weather – Extreme Weather

Observation / Measurement System Requirements: Describe how you want to observe or measure the phenomena. Consider the following:

Instrument / Payload characteristics (type, weight, volume, environmental considerations, and access such as sampling or viewing ports)

- TYPE
 - *High altitude platform*
 - *Remote sensing sounder (temperature and water vapor)*
 - *Cloud and Precipitation radar and radiometer*
 - *Electrical and lightning*
 - *Dropsonde (when possible)*
- PAYLOAD CHARACTERISTICS
 - *Payload weight*
 - *Total payload ~1000 lbs*
 - *Power ~1-2 KW*
 - *No special considerations for environments*
 - *Sufficient downward viewing for radiometer and radar*
 - *Possible pod for dropsonde system*

Flight characteristics (location, altitude, endurance, season, frequency). Discuss number of platforms, formation flying, or other special flight characteristics.

LOCATION, ALTITUDE, ENDURANCE, ETC

- Mission guided by satellite and ground-based measurement systems
- Targeted and adaptive operation with real-time human intervention (mixed initiative)

AIRCRAFT

- High Altitude Platform
 - Altitude* - 15-20 km (depending on the event, needs to clear the storm tops with sufficient margins)
 - Temporal Coverage - Continuous coverage during life cycle of storm event (lagrangian)
 - Endurance/spatial Coverage – 200 km to 1500 km (depending on event), 1-2 days
- Multiple viewing areas and down-looking ports
- Single platform
- Readiness - Target of opportunity
- *Alternative out of the box thinking - Ultra-high altitude (e.g. 100K+ ft) observing location. This will affect instrument design and could serve as a suborbital satellite testbed.

Communication needs such as real-time data or instrument control

Weather – Extreme Weather

- Real-time telemetry and on-board processing (sensor web)
- 300 Kbits/second (eg. 1 –2 TDRSS size demand access channels)
- Real-time instrument control, low bandwidth
- Evolution to autonomous or supervised tracking

Mission Concept: Describe in as much detail as possible the measurement approach:

Provide a narrative describing a “day-in-the-life” of the mission.

- Strategic decisions based on satellite and/or ground-based observations
- Adaptive release of microphysics sondes and dropsondes when possible
- Autonomous / semi-autonomous

Develop a diagram showing flight profile or maneuvers in time, space and/or geographic coordinates.

(no input)

Identify any special or unique platform or mission issues

(no input)

Summarize the key elements of the mission concept for this measurement.

- Process studies involving severe and hazardous weather events to improve the physics in mesoscale models (parameterizations)
- Improve parameterizations for mesoscale models
 - Winter storm hazards determine at local levels for appropriate mitigation
 - Regional forecasting of rain and snow accurate for economic decisions

Weather – Forecast Initialization

Critical Observation: Forecast initialization

Observation / Measurement Definition: Describe the phenomenon you want to observe. Describe what you need to measure.

- Research element – Determining data sensitive regions (e.g. THORPEX, atmospheric rivers)
- Operational/tech transfer pathway - e.g. NOAA/NCEP winter storms program
- Short term – 24 hr initialization (events already formed)
- Event oriented, fly ocean regions
 - Eastern Pacific (as an example)
 - Northern Atlantic
 - Arctic/Antarctic
- With remote sensing instruments/in-situ and high resolution vertical profiling (beyond satellites), including assimilating satellite data
- Longer term – 3-7 day (running forecast models backwards)
- Satellite validation (e.g. GPM and GIFTS Validation, improved use of satellite for forecasting)

Explicitly state how this observation and measurement supports this Earth Science focus area.

- Supports NASA/NOAA collaborative centers and high resolution global measurements

Explicitly state the advantage of using a suborbital platform for this measurement.

- Cannot/may not be able to obtain necessary vertical resolution from satellites

Identify other cross-cutting areas impacted by this observation.

- Global water and energy cycle
- Climate observations
- Supports Other Government Agencies (e.g. NOAA, FEMA)

Weather – Forecast Initialization

Observation / Measurement System Requirements: Describe how you want to observe or measure the phenomena. Consider the following:

Instrument / Payload characteristics (type, weight, volume, environmental considerations, and access such as sampling or viewing ports)

- Same as Hurricane (mostly high altitude)
- Payload weight
- Total payload ~1000 lbs (e.g. radiometer(s) ~100 lbs, radar ~150 lbs, wind lidar ~300 lbs, FTIR ~100 lb, dropsondes)

Flight characteristics (location, altitude, endurance, season, frequency). Discuss number of platforms, formation flying, or other special flight characteristics.

- Same as Hurricane, but slightly lower altitude (50K ft, region dependant).

Communication needs such as real-time data or instrument control

- Same as Hurricane

Weather – Forecast Initialization

Mission Concept: Describe in as much detail as possible the measurement approach:

Provide a narrative describing a “day-in-the-life” of the mission.

- Launch one or more suborbital platforms to begin/develop circuit.
- Real-time re-tasking of one or more platforms out of circuit to sensitive zones.
- Deployment of expendable or reusable/redockable sondes at regular and special locations/times.
- Real-time data assimilation into forecast models

Develop a diagram showing flight profile or maneuvers in time, space and/or geographic coordinates.

- Baseline circuit (10K km long, sampling low/high density regions ~20-200 km) with adaptive vectoring to sensitive regions, such as fronts (grid search).
- Time-criticality
 - Need to complete grid in 1/2 day (speed dependant, enhanced via model-based decision support (e.g. OSS/E))
- Total circuit – several days

Identify any special or unique platform or mission issues

- Redockable daughtership
- Long distance and endurance (above severe weather)

Summarize the key elements of the mission concept for this measurement.

- Research element – Determining data sensitive regions (e.g. THORPEX, atmospheric rivers)
- Operational/tech transfer pathway - e.g. NOAA/NCEP winter storms program
- Short term – 24 hr initialization (events already formed)
- Event oriented, fly ocean regions
 - Eastern Pacific (as an example)
 - Northern Atlantic
 - Arctic/Antarctic
- With remote sensing instruments/in-situ and high resolution vertical profiling (beyond satellites), including assimilating satellite data
- Longer term – 3-7 day (running forecast models backwards)

Weather – Hurricane Genesis, Evolution, and Landfall

Critical Observation: Hurricane genesis, evolution, and landfall

Observation / Measurement Definition: Describe the phenomenon you want to observe. Describe what you need to measure.

- High altitude remote sensing – precipitation, clouds, meteorological sounding, electrical, microphysics, dust
- Tropospheric – 4-D data cubes of thermodynamic variables and winds in (in situ microphysics)
- Boundary Layer – sea surface temperature and surface winds, surface imaging, turbulent fluxes, surface state (wave spectra, sea spume, etc,)

Explicitly state how this observation and measurement supports this Earth Science focus area.

(no input)

Explicitly state the advantage of using a suborbital platform for this measurement.

- Human safety
- Higher spatial and temporal resolution sampling
- Continuous observation
- Long endurance and range (access to sparsely sampled regions)
- Multi-platforms and constellation flying
- Real-time telemetry and on-board processing (sensor web)

Identify other cross-cutting areas impacted by this observation.

- Water and Energy Cycle
- Satellite validation (GPM, CloudSAT/CALIPSO, Aqua, NPOESS)
- Numerical weather prediction
- Atmospheric composition (water vapor)

Weather – Hurricane Genesis, Evolution, and Landfall

Observation / Measurement System Requirements: Describe how you want to observe or measure the phenomena. Consider the following:

Instrument / Payload characteristics (type, weight, volume, environmental considerations, and access such as sampling or viewing ports)

TYPE

- High altitude Platform
 - Meteorological sonde instruments (in situ)
 - Dropsonde (meteorological)
 - Remote sensing sounder (temperature and water vapor)
 - Cloud and Precipitation radar and radiometer
 - Electrical and lightning
 - Surface wave spectra (GPS reflectance, lidar)
 - Visible imaging for eyewall (Rossby waves)
 - Profiling lidar
- Tropospheric
 - Dropsondes
 - (Microphysics)
- Boundary layer
 - Infrared pyrometer (SST)
 - In situ winds (new instrument development)
 - Surface imaging (visible)
 - Turbulent fluxes (new instrument development)
 - Meteorological sonde instruments (in situ)

Flight characteristics (location, altitude, endurance, season, frequency). Discuss number of platforms, formation flying, or other special flight characteristics.

- LOCATION, ALTITUDE, ENDURANCE, ETC
 - Target tropical cyclone by ocean basin
 - One storm at a time (testbed demonstration)
 - Aircraft assets (minimum – 1 high altitude, 2 tropospheric, 5 boundary layer)
 - Adaptive flight formation guided by satellite and high altitude aircraft
 - Autonomous operation with real-time human intervention (mixed initiative)

Weather – Hurricane Genesis, Evolution, and Landfall

- AIRCRAFT
 - High Altitude Platform
 - Altitude - Above 20 km (tradeoff with field of view)
 - Temporal Coverage - Continuous observations for two weeks (single or multiple sorties/platforms)
 - Spatial Coverage – 200 km to 1500 km
 - Multiple viewing areas and down-looking ports
 - Dropsonde
 - Smartsonde
 - Daughter ship (expendable or redockable)
- Tropospheric
 - Altitude – 6-12 km
 - Temporal Coverage - Continuous observations after genesis
 - Spatial Coverage – 200 km to 1500 km
 - All weather performance during lightning, icing, graupel, turbulence
 - Dropsonde
 - Smartsonde
 - Daughter ship (expendable or redockable)
- Boundary Layer
 - Altitude – 100m to 6 km
 - Temporal Coverage – Continuous observations for two weeks (multi-aircraft)
 - Spatial Coverage - 200 km to 1500 km

Communication needs such as real-time data or instrument control

- Real-time telemetry and on-board processing (sensor web)
- 300 Kbits/second (eg. 1 –2 TDRSS size demand access channels)
- Real-time instrument control, low bandwidth
- Wideband, line of sight communication link for multi-platform network
- Evolution to autonomous or supervised tracking

Weather – Hurricane Genesis, Evolution, and Landfall

Mission Concept: Describe in as much detail as possible the measurement approach:

Provide a narrative describing a “day-in-the-life” of the mission.

- Formation flying
- Adaptive release of sondes or daughter ships
- Autonomous / semi-autonomous
- Decision support tools leading to autonomous operations

Develop a diagram showing flight profile or maneuvers in time, space and/or geographic coordinates.

(no input)

Identify any special or unique platform or mission issues

- Hi-band Communication
- Redocking or recoverable
- Daughter ship
- Controlled, reusable sondes

Summarize the key elements of the mission concept for this measurement.

- Formation flying in 3 altitude ranges
- Adaptive flights
- Mother/daughter ship
- Redockable or recoverable
- Autonomous tracking

Weather

Key Messages

Key Metric:

- Forecast improvement

Key Tasks:

- Bridge the gap between research/process studies and operational applications

Key capabilities:

- Real-time data downlink
- High resolution
- Cutting-edge remote sensors/platforms
- Adaptive, event-driven observations (hurricanes, winter storms, flooding); regional events

Key activities:

- Research
 - Downward-looking capabilities
 - Real-time high resolution data down-linking data capabilities
 - Process studies
 - What observations/assimilation are important
 - How to interpret them
 - Parameterization/applications
- Operational transfer
 - Partnerships (e.g. SPoRT, Joint Center)
 - NASA technology contributing to forecast improvements

*Still wish to solicit additional input from others in the broader weather community (e.g. modelers)